MX-774
GROUND TO GROUND MISSILE

ACTIVITY

CVAC REPORT 1496 18

JULY AND AUGUST 1948

CONSOLIDATED VULTEE

SAN DIEGO DIVISION, SAN DIEGO, CALIFORNIA

Confidential

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NOTICE

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FOREWORD

THE MX-774, UNDER DEVELOPMENT BY CONSOLIDATED VULTEE AIRCRAFT CORPORATION AT SAN DIEGO, CALIFORNIA IS A GUIDED MISSILE INTENDED FOR UPPER ATMOSPHERE SOUNDING. THE PROJECT, ORIGINALLY A STUDY AND RESEARCH PROGRAM, HAS ADVANCED THROUGH THE DESIGN STAGE AND CURRENTLY THREE MX-774 TEST MISSILES ARE IN CONSECUTIVE STAGES OF CONSTRUCTION, PREPARATORY TO ENTERING A FLIGHT TEST PROGRAM AT WHITE SANDS PROVING GROUND, LAS CRUCES, NEW MEXICO.

A BRIEF BUT COMPREHENSIVE REPORT ON THE PROJECT RELATING TO STABILIZATION, GUIDANCE, AND THE TESTING OF COMPONENTS IS ISSUED AT INTERVALS TO RECORD CURRENT ACTIVITIES.

THIS IS THE EIGHTEENTH IN A SERIES OF ACTIVITY REPORTS RELATING TO THE MX-774 PROJECT AND COVERS THE PERIOD BETWEEN 1 JULY AND 31 AUGUST 1948.

CONTENTS

ILLUSTRATIONS

SUMMARY

THE FIRST MX-774 WAS LAUNCHED AT WHITE SANDS PROVING GROUND, LAS CRUCES, NEW MEXICO ON 13 JULY 1948.

AN EDITED AND TITLED 16-MM DOCUMENTARY FILM COVERING PREPARATION AND FLIGHT OF NO. 1 TEST MISSILE WAS COMPLETED.

THE FABRICATION AND ASSEMBLY OF FLIGHT TEST MISSILE NO. 2 WAS COMPLETED AND PASSED INSPECTION ON 6 AUGUST 1948.

THE STATIC TEST FOR FLIGHT TEST MISSILE NO. 2 WAS CONCLUDED ON 30 AUGUST 1948 AT THE CONVAIR TEST FACILITY ON POINT LOMA.

CONVAIR REPORT NO. ZN-6002-007 ENTITLED "GUIDANCE SYSTEM FOR THE MX-774 MISSILE" WAS COMPLETED.

CONVAIR REPORT NO. ZN-6002-011 ENTITLED "ATMOSPHERIC REFRACTION ERRORS AND THEIR EFFECT UPON THE HITTING ACCURACY" WAS COMPLETED.

CONVAIR REPORT NO. ZN-6002-017 ENTITLED "PHASE COMPARISON ANGLE TRACKING SYSTEM" WAS COMPLETED.

THE NEXT ACTIVITY REPORT, NO. 1496-19 WILL COVER THE PERIOD 1 SEPTEMBER TO 31 OCTOBER 1948.

SECTION I

DESCRIPTION OF MISSILE

A. GENERAL

THE MX-774 TEST VEHICLE IS A SELF-LAUNCHED, HIGH ALTITUDE SUPERSONIC ROCKET PROJECTILE PROPELLED BY AN ALCOHOL/OXYGEN ENGINE OF 8000-POUNDS THRUST. IT IS BEING DEVELOPED TO STUDY POWER PLANT, CONTROL, GUIDANCE, AERODYNAMIC AND TRAJECTORY PROBLEMS. FIGURE 1 PROVIDES A VIEW OF FLIGHT TEST MISSILE NO. 1 ON THE LAUNCHING TABLE AT WHITE SANDS PROVING GROUND, LAS CRUCES, NEW MEXICO. THE INBOARD PROFILE IS SHOWN AS FIGURE 2.

B. PRINCIPAL CHARACTERISTICS

LENGTH (OVERALL)	31 FT. 7 IN.
DIAMETER (FUSELAGE)	30 IN.
SPAN (TAIL SURFACES PLUS FUSELAGE)	82.24 IN.
WEIGHT (GROSS)	4095 LB.
WEIGHT (EMPTY)	1205 LB
ALCOHOL (196 GAL AT 6.8 LB/GAL)	1332 LB
LIQUID OXYGEN (157 GAL AT 9.5 LB/GAL)	1500 LB
HYDROGEN PEROXIDE (5 GAL AT 11.6 LB/GAL)	58 LB
POWER PLANT (RMI ENGINE X8000c4 WITH X8M400C TURBINE - 4 ROCKETS 2000 LB THRUST EACH)	396.9 LB

C. AIRFRAME

THE MISSILE IS MADE UP OF AN ALL METAL AIRFRAME CONSISTING ESSENTIALLY OF A FUSELAGE NOSE SECTION, FUSELAGE CENTERSECTION AND AN EMPENNAGE OR TAIL SECTION.

THE FUSELAGE NOSE SECTION IS OF ALUMINUM ALLOY CONSTRUCTION AND HOUSES THE ELECTRICAL, STABILIZATION AND GUIDANCE CONTROL SYSTEM COMPONENTS. ALSO INCLUDED IN THE TEST MISSILE IS AN INSTRUMENTATION PANEL, TELEMETER EQUIPMENT, TWO GUN CAMERAS AND A RIBBON TYPE PARACHUTE.

THE ALCOHOL AND LIQUID OXYGEN TANKS FORMING THE ENTIRE FUSELAGE CENTER SECTION ARE OF WELDED ALUMINUM CONSTRUCTION. TWO REMOVABLE FAIRINGS HOUSING ELECTRICAL WIRING AND PRESSURE LINES ARE MOUNTED EXTERNALLY. THE ALCOHOL TANK IS SERVICED THROUGH A FILLER NECK LOCATED BETWEEN THE TANKS BY REMOVING AN ACCESS PANEL. THE LIQUID OXYGEN TANK IS SERVICED THROUGH A FILLER VALVE LOCATED AT THE BOTTOM OF THE CENTER SECTION.

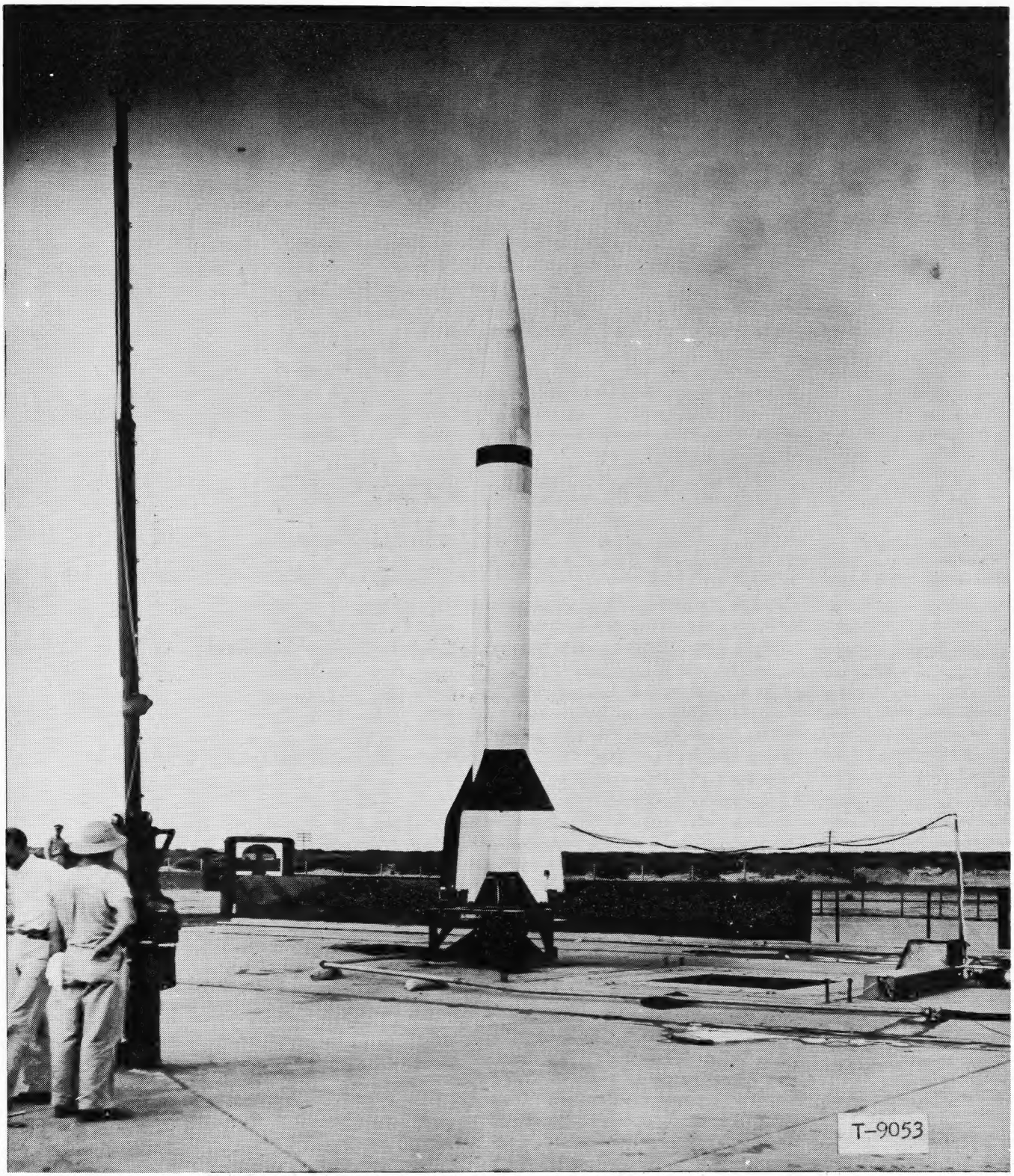
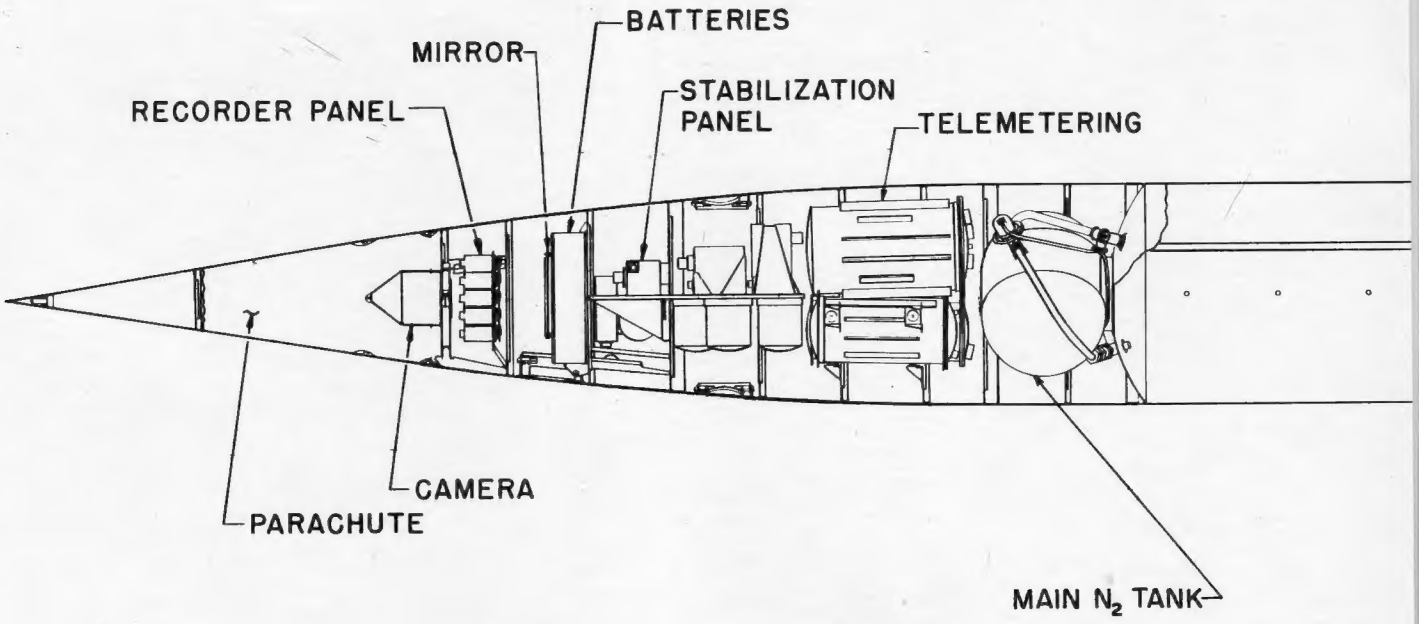
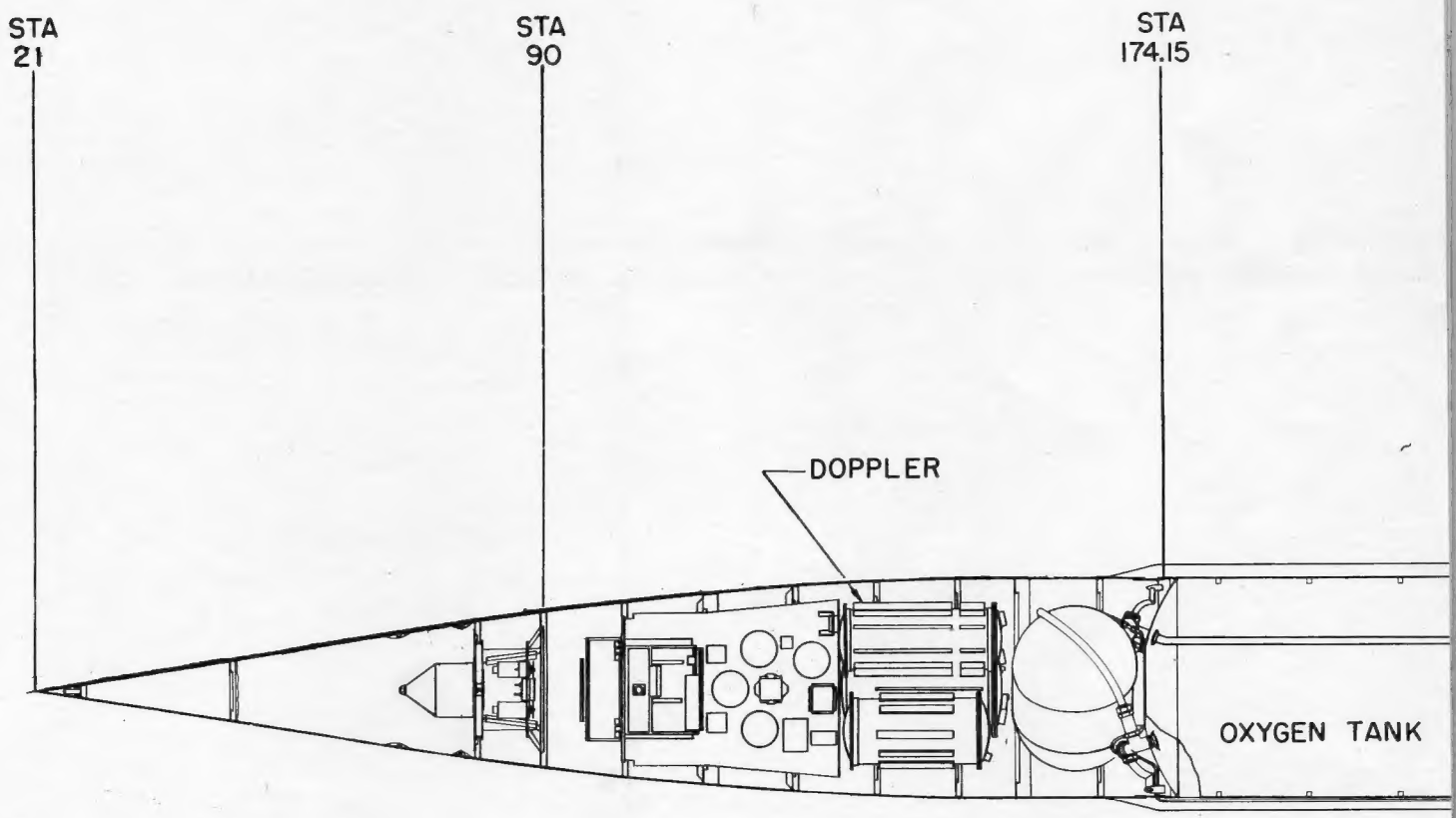


FIG. 1. - MX-774 FLIGHT TEST MISSILE NO. 1


BATTERIES
MIRROR
RECORDER PANEL
STABILIZATION PANEL
TELEMETERING
CAMERA
PARACHUTE
MAIN N_2 TANK


STA 21
STA 90
STA 174.15
DOPPLER
OXYGEN TANK

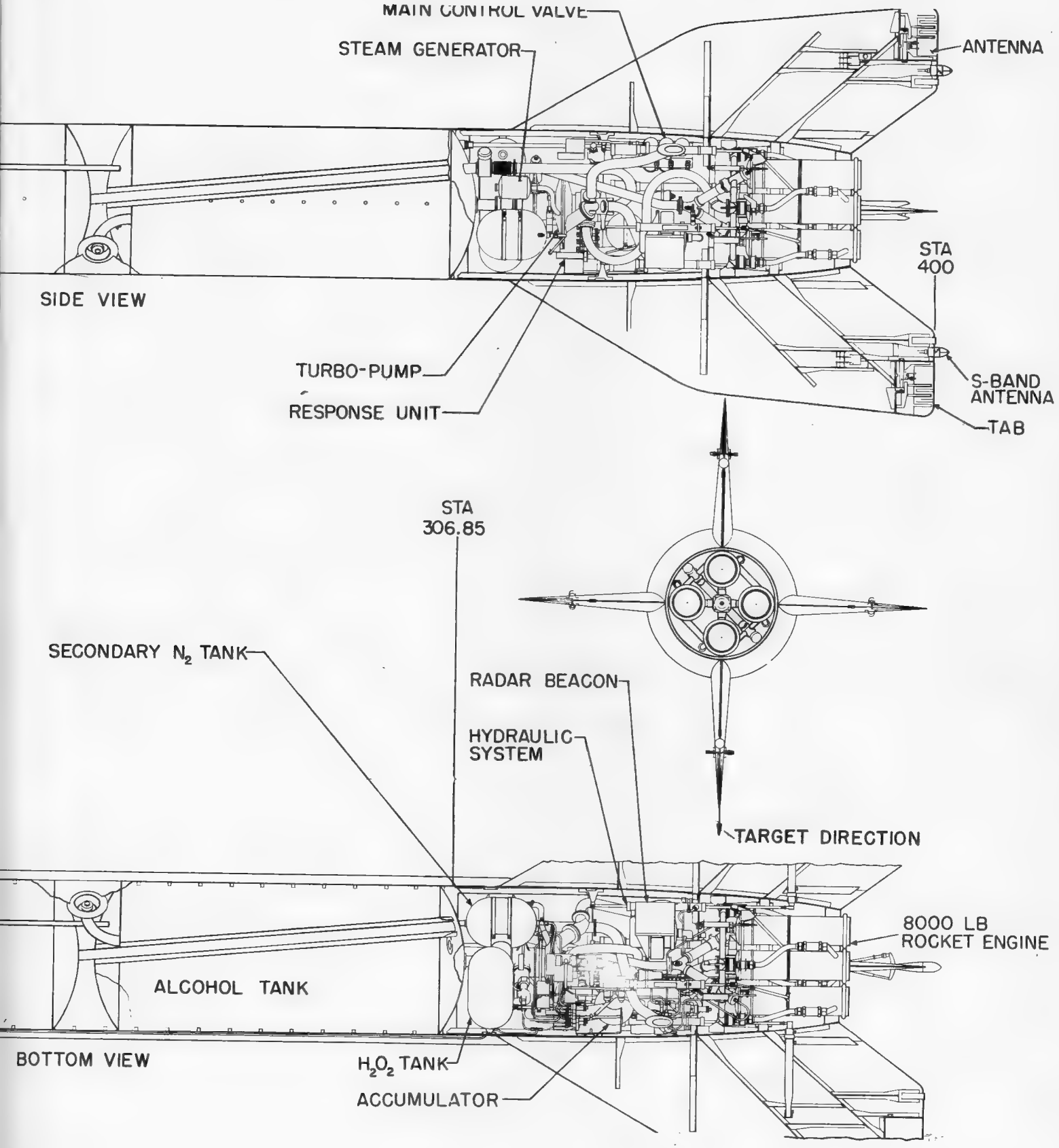


FIG. 2. – MX-774 INBOARD PROFILE

THE EMPENNAGE IS AN ALUMINUM ALLOY SEMI-MONOCOQUE STRUCTURE. IT HOUSES AND SUPPORTS THE POWER PLANT WITH ITS COMPONENTS AND THE CONTROL SURFACES OR TAIL GROUP ASSEMBLY. FIGURE 3 SHOWS THE EMPENNAGE MOUNTED IN THE ASSEMBLY FIXTURE.

THE TAIL GROUP CONSISTS OF FOUR FIXED FULL-CANTILEVER SURFACES, EACH CONTAINING A CONTROL TAB.

D. PROPULSION SYSTEM

THE POWER PLANT INSTALLATION, FIGURE 4, COMPRISES A REACTION MOTORS, INC. ALCOHOL/OXYGEN ROCKET ENGINE, MODEL X8000-C4 WITH X8M400C TURBINE. THE ENGINE CONSISTS OF FOUR 2000-POUND THRUST ROCKET CYLINDERS SWIVEL MOUNTED TO A TUBULAR STEEL MOUNT WHICH ALSO SERVES AS THE ALCOHOL MANIFOLD. MOUNTED IN THE MANIFOLD ARE TWO PROPELLANT VALVES ADMITTING FLOW FROM THE ALCOHOL PUMP. OXYGEN IS ADMITTED DIRECTLY FROM AN OXYGEN PROPELLANT VALVE THROUGH A SWIVELING JOINT AND CHECK VALVE TO EACH CYLINDER.

THE ROCKET CYLINDERS ARE SWIVELED PLUS OR MINUS 10 DEGREES FROM NEUTRAL POSITION BY MEANS OF HYDRAULIC ACTUATING CYLINDERS TO CONTROL THE MISSILE IN PITCH, ROLL AND YAW.

E. STABILIZATION SYSTEM

A CONVAIR DEVELOPED STABILIZATION SYSTEM IS INCORPORATED FOR CONTROLLING THE MISSILE IN PITCH, ROLL AND YAW BY SWIVELING THE FOUR INDIVIDUAL ROCKETS. AUXILIARY AERODYNAMIC CONTROL IS PROVIDED BY TWO MECHANICALLY CONTROLLED TABS WITH PLUS OR MINUS 10 DEGREES THROW IN PITCH COMBINED WITH PLUS OR MINUS 10 DEGREES ROLL DIFFERENTIAL AND TWO ELECTRICALLY CONTROLLED TABS WITH PLUS OR MINUS 20-DEGREE DIFFERENTIAL IN ROLL.

THE STABILIZATION SYSTEM INCORPORATES A COMBINATION ELECTRICAL AND HYDRAULIC CONTROL SYSTEM. EFFECTS OF A MISSILE PITCH, ROLL OR YAW ON THE STABILIZATION GYROS ARE FIRST CONVERTED INTO ELECTRICAL ERROR SIGNALS WHICH ARE PROPORTIONAL IN SIGN AND MAGNITUDE TO THE MISSILE DISPLACEMENT AND RATE OF DISPLACEMENT. THE STABILIZATION SYSTEM ALSO INCLUDES INTEGRAL CONTROL UNITS FOR PITCH, ROLL AND YAW TO CORRECT FOR MANUFACTURING MISALIGNMENTS OR UNBALANCED CONDITIONS WHICH MAY OCCUR. THE ELECTRICAL ERROR SIGNALS FROM THESE COMPONENTS AND FROM ROCKET POSITION FEEDBACKS ARE MIXED, AMPLIFIED AND CONVERTED INTO PROPORTIONAL HYDRAULIC VALVE DISPLACEMENTS. VALVE ACTIONS ARE FOLLOWED BY INDIVIDUAL POWER CYLINDER MOVEMENTS WHICH CHANGE THE ANGULAR POSITIONS OF THE FOUR ROCKET CYLINDERS TO CORRECT THE MISSILE'S ATTITUDE.

FIG. 3. - MX-774 EMPENNAGE ASSEMBLY

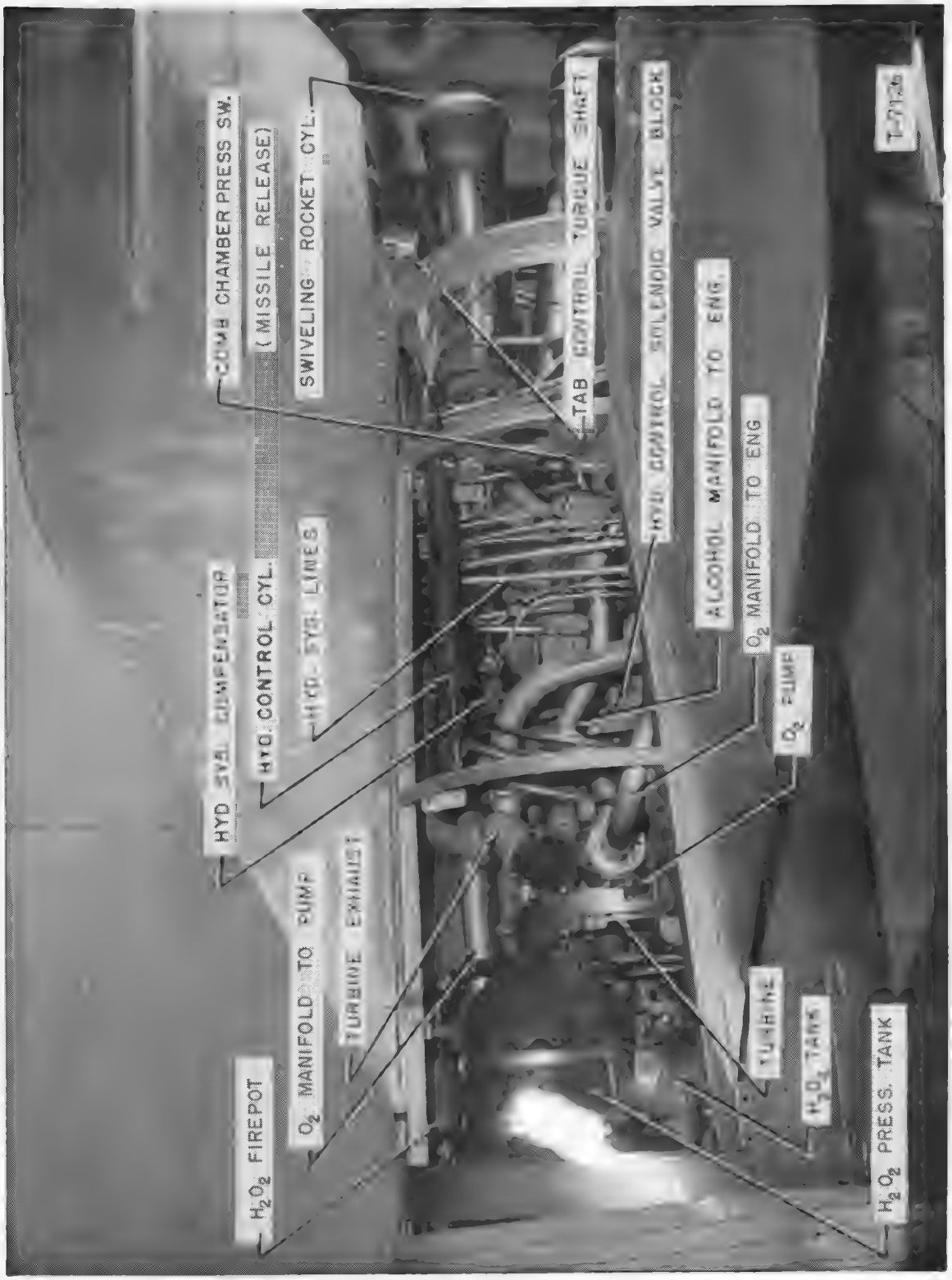


FIG. 4. - MX-774 POWER PLANT INSTALLATION

POWER FOR OPERATING THE HYDRAULIC CYLINDERS IS SUPPLIED BY A POWER CYLINDER FOR EACH OF THE PITCH, ROLL AND YAW SYSTEMS. THE SYSTEM OPERATES ON ALCOHOL PRESSURE FROM THE FUEL PUMP DISCHARGE.

FLIGHT CONTROL OF RANGE IS ACCOMPLISHED BY EITHER A MISSILE BORNE PROGRAM UNIT OR A GROUND BASED COMMAND UNIT THAT SHIFTS THE REFERENCE COORDINATES OF THE STABILIZATION SYSTEM.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO, CALIFORNIA

ERRATA SHEET

CVAC REPORT 1496-18 ENTITLED MX-774 GROUND TO GROUND MISSILE

ON PAGE 9, SECTION III, PARAGRAPH 2, FIRST LINE:

PERCENT SHOULD READ DEGREES

SECTION II
DESIGN AND FABRICATION

A. GENERAL

THE FABRICATION AND ASSEMBLY OF FLIGHT TEST MISSILE NO. 2 WAS COMPLETED AND PASSED INSPECTION ON 6 AUGUST 1948.

THE FABRICATION AND ASSEMBLY OF FLIGHT TEST MISSILE NO. 3 IS APPROXIMATELY 65 PERCENT ACCOMPLISHED.

A CHANGE WAS MADE IN THE POWER PLANT CIRCUITS FOR MISSILES NO. 2 AND NO. 3 WHICH CHANGES THE STARTING PROCEDURE. THE INTERNAL BATTERY IN THE NEW SYSTEM WILL NOT BE CONNECTED, IN CASE THE SQUIBS DO NOT FIRE. THIS ELIMINATES THE NECESSITY OF CHANGING THE BATTERY IN CASE OF A MISFIRE. TWO RELAYS IN THE ENGINE SYSTEM OF THE MISSILE WERE ALSO ELIMINATED THUS MAKING A MORE POSITIVE ELECTRICAL SYSTEM DURING FLIGHT.

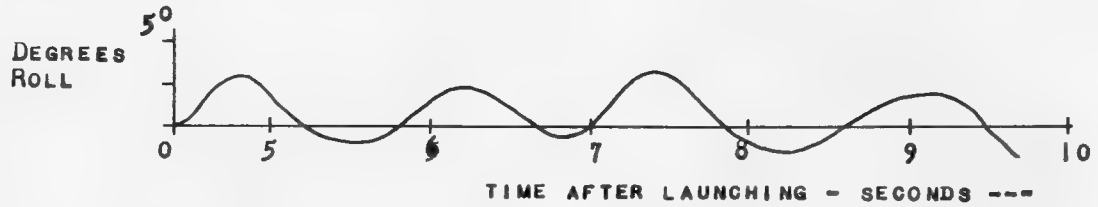
SECTION III
DYNAMICS ANALYSES

A. STABILIZATION SYSTEM STUDY

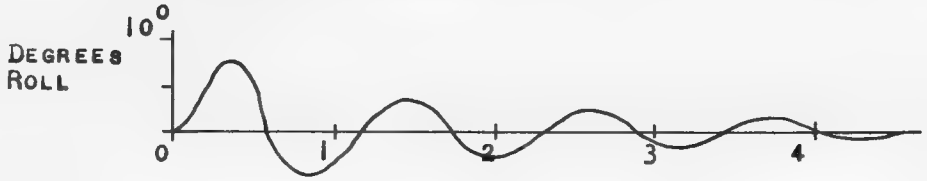
WORK DURING THIS PERIOD WAS CONFINED TO CHECKING PERFORMANCE OF THE STABILIZATION SYSTEM DURING FLIGHT OF MISSILE NO. 1, CONTINUATION OF REPORT ZU-6002-001 ENTITLED "DYNAMIC ANALYSIS OF THE STABILIZATION SYSTEM" AND TO A STUDY OF THE "CHATTER" OF THE SERVO-MOTORS DUE TO MECHANICAL COUPLING BETWEEN JETS AND RATE GYRO.

FOLLOWING THE FLIGHT, AN INVESTIGATION OF THE ± 2 PERCENT UNDAMPED ROLL WAS MADE. IT WAS DISCOVERED THAT THE RATE GYRO SIGNAL DID NOT HAVE OPTIMUM ADJUSTMENT. FIGURE 5 SHOWS COMPARISON OF (A) ACTUAL MISSILE ROLL OSCILLATION DURING FLIGHT (B) PERFORMANCE WITH RATE CONSTANT USED IN FLIGHT AS CALCULATED FROM SYSTEM CONSTANTS DETERMINED BY ANALOG-COMPUTER ANALYSIS, AND (C) ROLL OSCILLATION OF SIMULATOR WITH RATE CONSTANT USED IN FLIGHT OF MISSILE NO. 1.

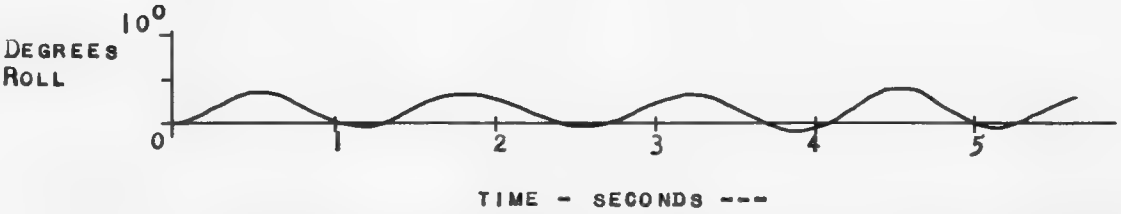
A DISCUSSION OF THE "CHATTER" STUDY IS TO BE INCLUDED IN REPORT ZU-6002-001.



(A) MISSILE #1 ROLL OSCILLATION DURING FLIGHT, WSPG 13 JULY, 1948. SERVO CONSTANTS: FREE: 0.08 RATE: 0.005 FOLLOW-UP: 0.35. (RATE CONSTANT 1/3 THAT RECOMMENDED FROM CIT ANALOG COMPUTER ANALYSIS.) CURVE PLOTTED TO SCALE FROM TELEMETERING RECORDS.



(B) CALCULATED ROLL OSCILLATION FOR SERVO CONSTANTS USED IN FLIGHT OF MISSILE #1.



(C) ROLL OSCILLATION OF WATER-JET SIMULATOR FOR SERVO CONSTANTS USED IN FLIGHT OF MISSILE #1. (RECORD MADE AFTER THE FLIGHT).

FIG. 5. - MX-774 COMPARISONS OF ROLL OSCILLATIONS

SECTION IV

TEST PROGRAMS

FLIGHT TEST MX-774 NO. 1

A. GENERAL

THE FIRST MX-774 WAS LAUNCHED FROM THE CONVAIR LAUNCHING TABLE AT 1804 MST (6:04 PM) ON 13 JULY 1948 AT WHITE SANDS PROVING GROUND, LAS CRUCES, NEW MEXICO.

AN EDITED AND TITLED 16-MM DOCUMENTARY FILM COVERING PREPARATION AND FLIGHT OF THE MX-774 TEST MISSILE WAS COMPLETED.

FIGURE 6 SHOWS THE ACTIVE MISSILE DURING THE FLIGHT TEST AND IS AN ENLARGEMENT OF TWO FRAMES OF THE DOCUMENTARY FILM.

NORMAL OPERATION OF ALL COMPONENTS WAS CHECKED OUT SATISFACTORILY DURING THE EIGHT HOUR AND FORTY-FIVE MINUTE PERIOD PRECEDING THE LAUNCHING.

"MISSILE LIFT" OCCURRED AT 5.7 SECONDS AFTER CLOSING OF THE FIRING SWITCH.

IGNITION AND SEPARATION FROM THE LAUNCHING TABLE APPEARED NORMAL.

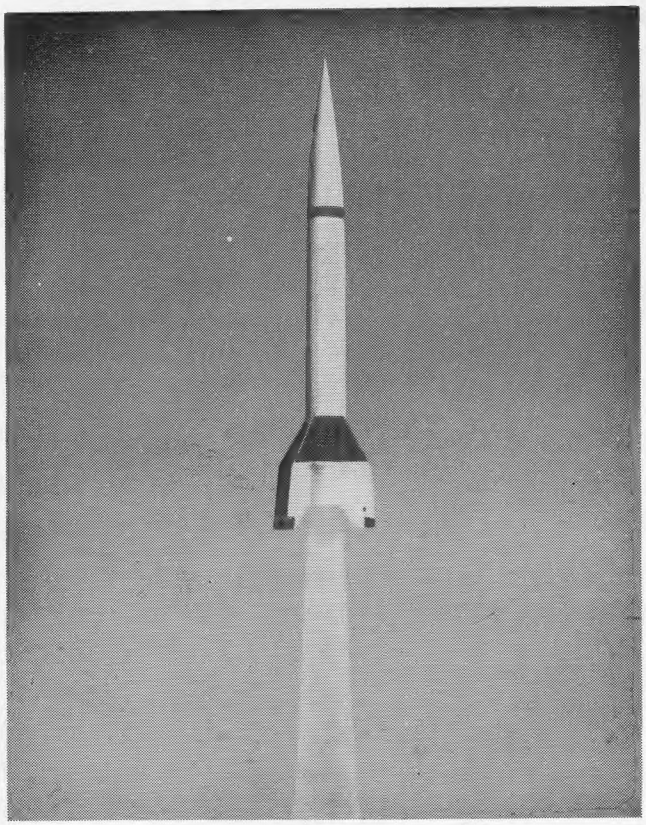
THE MISSILE STABILIZED IN PITCH, ROLL AND YAW DURING THE ENTIRE POWERED PORTION OF THE FLIGHT WHICH LASTED 12.6 SECONDS. THE MISSILE REACHED PEAK AT APPROXIMATELY 28 SECONDS WITH AN ALTITUDE OF 6228 FEET.

PARACHUTE RELEASE WAS ATTEMPTED BUT FAILED DUE TO OPERATOR ERROR. IMPACT OCCURRED AT 48.5 SECONDS. THE MISSILE EXPLODED ON IMPACT DUE TO THE LARGE AMOUNT OF OXYGEN AND ALCOHOL REMAINING IN THE TANKS. THE INTERNAL PHOTO RECORDER CAMERA WAS SALVAGED SUFFICIENTLY TO ALLOW DEVELOPMENT OF THE FLIGHT FILM.

B. STABILIZATION SYSTEM RESULTS

OPERATION OF THE STABILIZATION SYSTEM APPEARED SATISFACTORY DURING THE POWERED PORTION OF THE FLIGHT.

ASKANIA THEODOLITE DATA SHOW A DEVIATION FROM THE VERTICAL OF 8-FEET SOUTH AND 11-FEET WEST AT 12.6 SECONDS AT AN ALTITUDE OF 2358 FEET. THE DEVIATION AT MAXIMUM ALTITUDE OF 6228 FEET WAS ABOUT 63-FEET NORTH AND 60-FEET WEST. THIS OCCURRED AT 28.15 SECONDS. AT THE TIME OF IMPACT



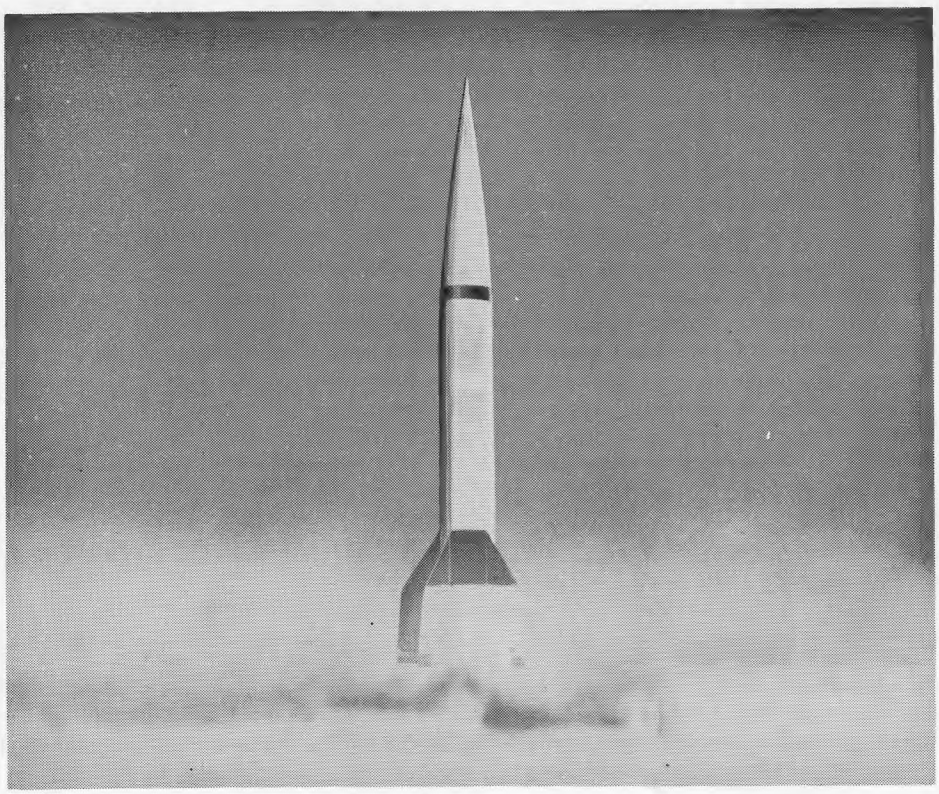


FIG. 6. – MX-774 FLIGHT TEST MISSILE NO. 1 – FLIGHT PHOTOGRAPHS

THE DEVIATION WAS 340-FEET NORTH AND 239-FEET WEST. FROM THIS DATA IT IS EVIDENT THAT THE PITCH AND YAW CONTROL WAS EXCELLENT DURING THE POWERED PORTION OF THE FLIGHT WHEN THE STABILIZATION SYSTEM WAS EFFECTIVE.

A LARGE ROLL DISTURBANCE ENCOUNTERED AT ABOUT 3 SECONDS (SEE FIGURE 7) WAS PROPERLY CORRECTED BUT A ROLL HUNT OF ABOUT ± 2 DEGREES AMPLITUDE AND 0.63 CYCLE PER SECOND FREQUENCY PERSISTED THROUGHOUT THE POWERED FLIGHT.

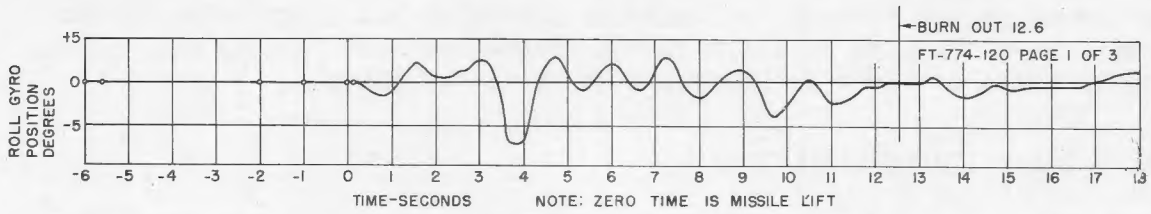


FIG. 7. - MX-774 TELEMETERED ROLL GYRO POSITION - FLIGHT TEST MISSILE NO. 1

C. TELEMETERING SYSTEM RESULTS

TELEMETERING SIGNALS IN GENERAL WERE POOR. THE SIGNALS WERE AFFECTED BY BATTERY VOLTAGE FLUCTUATION AND MOST CHANNELS SHOW EVIDENCE OF SUBCARRIER OSCILLATOR FREQUENCY DRIFT. MOST TRACES THEREFORE ARE UNRELEABLE AS TO MAGNITUDE OF THE QUANTITIES MEASURED. SOME USEFUL QUALITATIVE INFORMATION WAS OBTAINED. TIMING INFORMATION SUPPLIED BY TELEMETERING IS QUANTATIVELY ACCURATE. THE ROLL GYRO CURVE SHOWN IN FIGURE 7 IS ONE OF THE FEW USEFUL TELEMETERING TRACES.

D. PROPULSION SYSTEM RESULTS

THE PROPULSION SYSTEM OPERATION WAS SATISFACTORY UNTIL FAILURE AT 12.6 SECONDS. ALL TANK PRESSURES, MANIFOLD PRESSURES AND CHAMBER PRESSURES WERE STEADY THROUGHOUT THE RUN AND MEASURED UP TO REQUIRED VALUES. REFER TO FIGURE 8.

INDICATOR LIGHT DISCONTINUITIES SHOWN DURING THE RUN CAN BE TRACED BACK TO BATTERY VOLTAGE IRREGULARITIES RATHER THAN IMPROPER FUNCTIONING OF THE ENGINE.

PRIOR TO ACTUAL FIRING OPERATIONS, ALL SYSTEMS WERE CHECKED OUT FOR OPERATIONAL CHARACTERISTICS FOLLOWING PRESCRIBED CHECKOUT PROCEDURES. THE MISSILE WAS FUELED FOR FULL TIME OPERATION WHICH INCLUDED TOPPING OFF THE OXYGEN TANKS AND THE TWO NITROGEN TANKS.

CAUSE OF THE EARLY SHUT-DOWN OF THE PROPULSION SYSTEM HAS NOT BEEN DETERMINED. HOWEVER, THE ASSUMPTION OF A SHORT OR BROKEN WIRE IN THE MISSILE ELECTRICAL SYSTEM RESULTING IN THE CLOSING OF THE OXYGEN AND HYDROGEN-PEROXIDE PROPELLANT VALVES WOULD ACCOUNT FOR MOST OF THE PHENOMENA OBSERVED.

E. DOPPLER SYSTEM RESULTS

SATISFACTORY SIGNAL STRENGTH WAS RECEIVED FROM THE MISSILE AT THE DOPPLER GROUND STATION THROUGHOUT THE FLIGHT. DUE TO THE LOW ALTITUDE ATTAINED BY THE MISSILE THE VELOCITY VECTOR AT ALL TIMES MADE A LARGE ANGLE WITH THE LINE OF SIGHT TO THE GROUND STATION. THEREFORE, THE VELOCITY DATA OBTAINED BY DOPPLER WERE OF LITTLE VALUE.

F. RADAR BEACON RESULTS

THE RADAR BEACON FUNCTIONED SATISFACTORILY THROUGHOUT THE FLIGHT. PROVISIONS FOR ACTUATING EMERGENCY FUEL SHUT-OFF, PARACHUTE RELEASE AND DESTRUCTION CHARGE DETONATION WERE INCORPORATED ON THE RADAR BEACON.

G. INSTRUMENTATION RESULTS

GOOD DATA WERE OBTAINED FROM THE PHOTO RECORDER INSTRUMENTATION AND SIGNAL LIGHTS. GRAPHS OF FIGURES 8, 9 AND 10 ARE THE RESULT OF REDUCTION OF PHOTO RECORDER DATA.

FIGURE 11 SHOWS RESULTS FROM ASKANIA THEODOLITE AND RADAR TRACKING.

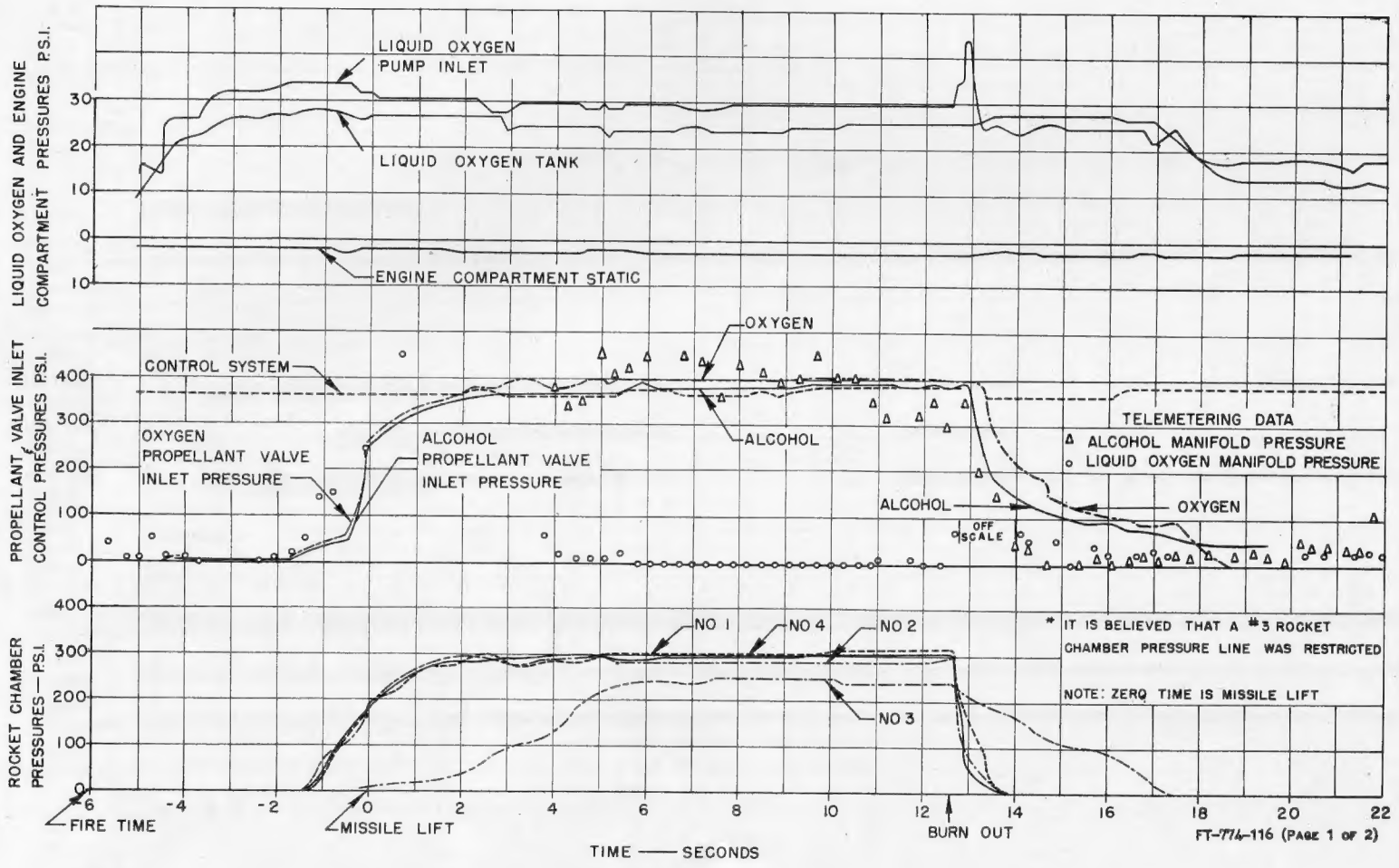


FIG. 8. – MX-774 POWER PLANT OPERATING PRESSURES